Problem Set 8

Power Cycles

Reference Textbook:


1) [T&K] Chapter 6, Problem 6-2

2) [T&K] Chapter 6, Problem 6-3

3) [T&K] Chapter 6, Problem 6-5

4) Consider a helium Brayton Cycle with regeneration, pressure losses, and real machines. These are characterized by the following parameters:

\[ \xi = 0.92 \]
\[ \beta = 1.025 \]
\[ \eta_t = \eta_c = 0.92 \]

The cycle operates at a pressure ratio of \( r_p = 2.2 \) between limiting temperatures of 303 K and 1083 K. For helium:

\[ \gamma = 1.66 \]
\[ c_p = 5.230 \text{ kJ/kg K} \]

For this cycle, find the thermal efficiency, \( \eta_{th} \). 

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5) In Example 6-10 it is shown that the cycle thermal efficiency of the simple Brayton cycle shown in Figure 6-24 can be increased by utilizing regeneration. Specifically, it was found that, with the addition of a regenerator of effectiveness 0.75, the cycle thermal efficiency was increased from 42.3% to 48.1%. Another way of improving the efficiency of the simple Brayton cycle is to use a bottoming cycle. To this end, consider the system shown in Figure 1. It shows the simple Brayton cycle with a Brayton bottoming cycle. For this system, the following parameters and information are known:
\[ T_1 = 278 \text{ K} \]
\[ T_3 = 972 \text{ K} \]
\[ T_9 = T_1 \]
\[ \gamma \text{ for both cycles} = 1.658 \]
\[ r_p \text{ for the simple Brayton cycle} = 4.0 \]
\[ c_p \text{ for both cycles} = 5230 \text{ J/kg K} \]
\[ \Delta T_p = \text{pinch point of heat exchanger #1} = 15^\circ C = T_4 - T_7 \]

Mass Flowrate for the simple Brayton cycle = twice the mass flowrate for the Brayton bottoming cycle

All turbine and compressors in both cycles are ideal

No duct pressure losses in either cycle

### Figure 1

#### QUESTIONS

A. Draw the T-s diagram for the entire system.

B. What must be the pressure ratio of Turbine #2 and Compressor #2 such that the cycle thermal efficiency of the entire system is maximized?

C. What is the maximum cycle thermal efficiency?

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